of a very narrow-minded conception of an unprogressive protestantism and had much trouble to rid himself of the dualistic errors which placed him from the start in a wrong attitude towards religion. For a long time he was very patient with his antagonists, and it is quite excusable if here and there he goes a little too far. Have not his enemies gone too far in their attacks on him? They have painted him as black as a devil. I need not add that Haeckel's love of truth, his sincerity, his scientific honesty, and the kindliness of his character are genuinely religious.

As to the main point, however, concerning my differences with Professor Haeckel, I feel sure that he agrees with me better than with himself, and I hope he will pardon me for the statement.

EDITOR.

SCHOPENHAUER ON NEWTON AND HOOKE.

[In connecton with Mr. Philip E. B. Jourdain's article on "Robert Hooke as a Precursor of Newton," we venture to publish these extracts from Schopenhauer's writings to call attention to his position with regard to the priority of the discovery of the laws of gravitation between Newton and Hooke. Although some of the details may be inaccurate, Schopenhauer often hits the nail on the head. It cannot be denied that indirectly or directly, Hooke provided a great stimulus for Newton.—ED.]

In order to appreciate the great value of the gravitation theory which Newton perfected, to say the least, and placed on a positive foundation, we must recall the state of perplexity in which thinkers had been for millenniums with regard to the movements of the celestial bodies. Aristotle represented the universe as composed of transparent concentric spheres, the outermost of which contained the fixed stars, each of the succeeding ones a planet, and the last the moon; the nucleus of the machine was the earth. Now, what the power was that kept this system constantly in rotation was a question to which he had nothing to say except that there must be a *πρῶτον κινοῦν* somewhere—and this answer men have since been so kind as to interpret as theism, whereas he did not teach the existence of a creative God, certainly not that the universe is eternal, and barely a first motive energy in his cosmology. But even after Copernicus had replaced that fabulous construction of the world-machine by the correct one, and also after Kepler had discovered the laws of its motion, there still remained the old perplexity with regard to the motive force. Aristotle had assigned to the spheres

an equal number of gods for their direction. The scholastics transferred this direction to certain so-called "intelligences," which is simply a more pretentious name for the good angels each of which now drove its own planet. Free thinkers like Giordano Bruno and Vanini later knew no better than to make the planets themselves a sort of living divinities. They were followed by Descartes who always tried to account for everything in a mechanical way, but could conceive of no other motive energy than impact. Accordingly he assumed an invisible and intangible substance which surrounded the sun in layers and pushed the planets forward, the Cartesian vortex.

How childish and trivial all this is, and how much therefore we ought to value a theory of gravitation which has demonstrated incontestably the motive causes and the forces effective in them, and this so positively and accurately that even the slightest deviation and irregularity, acceleration and retardation, in the course of a planet or satellite can be perfectly explained and exactly computed from its nearest cause!

Hence the fundamental notion of making gravitation, which is known to us directly only as weight, the controlling force of the planetary system, is such a supremely significant one because of the important consequences following upon it that an inquiry with regard to its origin deserves not to be set aside as irrelevant; especially as we ought to strive to judge correctly at least as posterity, since we are so seldom able to do so as contemporaries.

It is well known that in 1686[1] when Newton published his *Principia* Robert Hooke raised a hue and cry about his priority in its main contention; and also that the bitter complaints of himself and others forced from Newton the promise to mention them in the first complete edition of the *Principia* (1687), which he did with the fewest possible words in a scholium to Book I, prop. 4, cor. 6, in the parenthesis, "*ut seorsum collegerunt etiam nostrates Wrennus, Hookius et Hallaeus.*"

[1] The *Principia* was not published until the next year and there seems to be no evidence that any one but Newton and Halley saw the proof sheets in 1686 although it is possible that Halley showed them to his acquaintances. In April 1686 Halley announced to the Royal Society that the *Principia* was almost ready for the press, and soon afterwards the manuscript of the *first Book* was presented to the Society. The book was licensed to be printed in July, 1686 (the "Imprimatur" was signed on July 5). Printing was begun just before this, and the first sheet in proof was sent to Newton on June 7, 1686. The second Book of the *Principia* was not sent up for printing until March, 1687, and the third shortly after this. The complete work was published in the midsummer of 1687.

That in the year 1666 Hooke had already propounded the essential part of the gravitation theory (though simply as an hypothesis) in a "Communication to the Royal Society" we can see from the main passage of this treatise which is reprinted in Hooke's own words in Dugald Stewart's *Philosophy of the Human Mind,* II, p. 434. In the *Quarterly Review* of August 1828 there is a good concise history of astronomy which treats Hooke's priority as an established fact.

In Michaud's *Biographie universelle,* comprising about one hundred volumes, the article "Newton" seems to be a translation from the *Biographia Britannica* to which it refers. It contains the representation of the universe according to the law of gravitation literally and *in extenso* according to Robert Hooke's *An Attempt to Prove the Motion of the Earth from Observations,* London, 1674, 4o. The article further states that the main point, namely that gravitation extends to all the celestial bodies, had already been expressed in Borelli's *Theoria motus planetarum e causis physicis deducta,* Florence, 1666. Finally it gives Newton's long reply to Hooke's above-mentioned claim to the priority of discovery.

On the other hand the apple story which has been repeated *ad nauseam* is without foundation. It is first mentioned as a well-known fact in Turnor's *History of Grantham,* p. 160. Pemberton, it is true, who knew Newton personally, although only after he had become old and infirm, relates in the preface to his *View of Newton's Philosophy,* that the thought first occurred to Newton in a garden, but says nothing about the apple; this was a later plausible addition. Voltaire claims to have heard it orally from Newton's niece, which is probably the origin of the story. See Voltaire, *Elémens de philosophie de Neuton,* II, chap. 3. A note to Byron's *Don Juan* (Canto X, stanza 1) says: "The celebrated apple-tree, the fall of one of the apples of which is said to have turned the attention of Newton to the subject of gravity, was destroyed by wind about four years ago. The anecdote of the falling apple is mentioned neither by Dr. Stukeley nor by Mr. Conduitt, so, as I have not been able to find any authority for it whatever, I did not feel myself at liberty to use it.—Brewster's *Life of Newton,* p. 344."

To all these authorities contradicting the assumption that the great conception of universal gravitation is a brother to the fundamentally false theory of homogeneous light, I have one more argument to add, which to be sure is only a psychological one, but will

have considerable weight for those who know human nature also from its intellectual side.

It is a well-known and undisputed fact that Newton at a very early period, it is said as early as 1666, either of his own accord or with outside aid, had conceived the theory of gravitation and sought to verify it by applying it to the orbit of the moon; that nevertheless, because the result did not exactly agree with the hypothesis, he finally let the latter drop and abandoned the subject for many years. Equally well known is the cause of the discrepancy which frightened him away. It arose simply from the fact that Newton took the distance of the moon from the earth as almost $\frac{1}{7}$ too small, and this again because the distance can be first measured only in diameters of the earth; the diameter of the earth is computed from the length of the degrees of the circumference of the earth, and only these latter can be measured directly. Now Newton used the degree merely in its common geographical acceptation as containing 60 English miles in round numbers, whereas in fact it has 69½. The result was that the orbit of the moon did not agree with the hypothesis that gravitation is a force decreasing according to the square of the distance. Hence it was for this reason that Newton gave up the hypothesis and dismissed it. Not until about sixteen years later, that is, in 1682, did he learn of the measurement of degrees, completed by the Frenchman Picard some years previously, according to which the degree was almost $\frac{1}{7}$ larger than he had formerly supposed it to be. Without considering this of much importance he made a note of it in the Royal Society where it was communicated to him from a letter, and then proceeded to listen attentively to the lecture without being at all disturbed by the fact. Not until afterwards did the old hypothesis occur to him. He again took up his calculations with regard to it and now found the state of things to correspond to it exactly, whereupon he fell into great ecstasies, as everybody knows.

Now I ask every one who is himself a father, who has himself begotten hypotheses, who has fed them and nursed them, does a man thus treat his own children? When everything does not go just right, does he at once thrust them out of the house without mercy, slam the door shut, and not ask a word about them for sixteen years? Would he not much more likely in a case like the present, before pronouncing such a bitter "There's nothing in it," suppose the mistake to be anywhere, even in the creation of the Heavenly Father himself if need be, sooner than in his own beloved child that he had

brought into life and carefully cherished?—and especially in just that point where suspicion might so easily have found its rightful place, namely in the only empirical datum (besides the one angle) upon which the calculation was based, and whose uncertainty was so well known that the French had been carrying on their degree measurements since 1669, in spite of which uncertainty Newton nevertheless had made his assumption according to the popular acceptation in English miles. And a man could be so misled with a true and elucidating cosmic hypothesis? Never, *if it were his own*! On the other hand, I can tell you likewise what children are treated in this way: foundlings who are taken reluctantly into the home, at whom (on the arm of his own barren wife) the man looks askance with envious eyes and puts to a test only from a sense of duty, hoping they will not stand the test, and as soon as this is confirmed throws them out of the house with jeers of ridicule.

This argument is of such great importance, at least to me, that I recognize in it a complete corroboration of the evidence which ascribes the fundamental conception of gravitation to Hooke and leaves to Newton only its verification by calculations. According to this view Hooke has fared as badly as Columbus: the continent is called "America," and gravitation is called "Newton's theory."—*Parerga und Paralipomena,* II, Section 86.

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No science imposes upon the multitude so much as astronomy. Accordingly the astronomers who for the most part are ready reckoners of very ordinary capacity, put on great airs with their "most exalted science" and similar expressions. Even Plato joked about these claims and called to mind that what is exalted is not necessarily that which happens to be above us (Rep. L. VII).

The almost idolatrous veneration which Newton enjoys, especially in England, exceeds all belief. Just recently he was called in the *Times* "the greatest of human beings," and in another article in the same journal an attempt is made to console us with the information that we may feel assured that he nevertheless was only a man! In the year 1815 (according to the report of the weekly *Examiner,* printed in *Galignani,* Jan. 11, 1853) one of Newton's teeth was sold for 730 pounds sterling to a lord who had it set in a ring, which tale reminds us of the sacred tooth of Buddha. Now this ridiculous adoration of the great master of calculation rests on the fact that people take as the measure of his merits the size of

the masses whose movements he has reduced to their laws and these to the force of nature therein operative (which latter, moreover, was not his discovery but Robert Hooke's which he merely confirmed by calculation). Otherwise we cannot see why more honor is due him than to any other who has reduced given effects to the expression of a definite force of nature, and why, for instance, Lavoisier should not be valued as highly.—*Parerga und Paralipomena,* II, Section 80.

* * *

Hooke's discovery of the law of gravitation, and the reference of so many important phenomena to this one law, was the work of immediate apprehension by the understanding; and such also was the proof of Newton's calculations, and Lavoisier's discovery of acids and their important function in nature, and also Goethe's discovery of the origin of physical colors.—*World as Will and Idea* (ed. Haldane and Kemp), I, 26.

* * *

It cannot but disturb us very much if we find minds of the first order under suspicion of dishonesty, which would be a scandal to those of the lowest order. For we feel that theft is even more inexcusable in a rich man than in a poor one. We dare not, however, be silent; for here we are posterity, and must be just, as we hope that posterity will be some day to us. Therefore, as a third example,[2] I will add to these cases, that the fundamental thoughts of the "Metamorphosis of Plants" by Goethe, were already expressed by Kaspar Wolff in 1764 in his *Theory of Generation,* pp. 148, 229, 243, etc. Indeed, is it otherwise with the system of gravitation? The discovery of this is always ascribed to Newton on the continent of Europe, while in England the learned at least know very well that it belongs to Robert Hooke, who in the year 1666, in a communication to the Royal Society expounds it quite distinctly, although only as a hypothesis and without proof. The principal passage of this communication is quoted in Dugald Stewart's *Philosophy of the Human Mind,* and is probably taken from Robert Hooke's *Posthumous Works.*[3] The history of the matter, and how Newton got into difficulty by it, is also to be found in the *Biographie universelle,* article "Newton." Hooke's priority is treated as an established fact in a short history of astronomy in the *Quarterly*

[2] The first was Kant's dynamics previously expounded by Priestley; the second was Laplace preceded by Kant.—Ed.

[3] See Mr. Jourdain's article on another page.

Review, August, 1828. Further details on this subject are to be found in my *Parerga,* Vol. II, Section 86 (second edition, Section 88). The story of the fall of an apple is a fable as groundless as it is popular, and is quite without authority."—*World as Will and Idea* (ed. Haldane and Kemp), II, 225-226.

EARLIER THEORIES OF GRAVITY.

It is universally conceded that gravitation is the most incomprehensible of all forces. Gravitation is supposed to be included in the law of conservation of energy, and from one point of view there is doubtless evidence to show this. When a body is poised upon the edge of a table, let us say, it possesses a certain amount of potential energy. When that body falls to the ground, its potential is converted into actual or kinetic energy. The energy is therefore released from the body which now possesses none. The energy it once possessed has been expended and converted into the work of the world, or its energy has been radiated uselessly into space; and thus we see how gravitation, the attraction of the earth for all material bodies, can be made to enter into the circle of generally recognized forces and included in the law of conservation. It might be questioned whether potential energy *is* energy in the strictest sense of the term, but I shall let that pass for the moment and assume that these facts prove what they are said to prove.

Gravitation is certainly the most mysterious of all known forces, and even yet nothing definite can be said as to its *modus operandi.* In the case of all other forces known to us it is possible to shut off their influence, to find some body which is opaque to their power. Take, for instance, light and electricity. Roughly speaking, glass permits the passage through it of light rays but prevents the passage of electric rays. Steel on the contrary, being a good conductor, permits the passage through it of the electric current but is impervious to light. The same is true of all other forces with the single exception of gravitation. No body has been found opaque to gravitation. It seems to exert its influence above, below, and equally upon all sides of any object. The introduction of a solid sheet of metal, of glass, or of any substance whatever, seems to have no appreciable effect. The body beneath which it is introduced seems to be attracted to the earth by gravitation just as strongly as it was before the introduction of such a sheet. And yet, from all that we know of force and energy, such should not be the case! We are